Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

PRELIMINARY OBSERVATIONS UPON THE BRAIN OF AMPHIUMA.

BY HENRY F. OSBORN, SC. D.

The North American Urodela, embracing a wide variety of forms which can readily be obtained, offer an attractive field for the comparative study of the amphibian brain. The work upon the subject hitherto has been chiefly in Germany, but many members of this large group have barely been touched upon, so that a systematic research into the whole subject would form a valuable contribution to Comparative Morphology.

In the hope of extending my study later I have recently been investigating the brain of *Amphiuma*,[1] having procured a quantity of live specimens from New Orleans. This paper contains a preliminary account of this investigation.

Among the more important studies upon the amphibian brain are those of Wyman,[2] Fischer,[3] Stieda[4] and Wilder.[5] Stieda's work is principally upon the microscopic structure of the brains of the Frog and Axolotl; Wilder, in his study of the Frog and Menobranchus, has directed attention largely to parts of the brain which have been less studied hitherto, namely to the cavities and the thinner portions of the brain parietes surrounding them, as well as to the brain membranes. I am indebted to the writings of both of these authors for light upon this subject, although I have not as yet so fully consulted either as I would like to do.

In the general description the usual terminology of different portions of the brain is employed, but in referring to the various segments of the brain tube and to the ventricles they enclose I largely employ the terms partly adopted and partly introduced by Wilder. His system of nomenclature, which is chiefly founded upon the embryonic divisions of the brain, is admirably clear and consistent, although objections may be raised to the author's means of indicating position and direction.[1]

---

[1] I employ this title as it is the family name (*Amphiumidæ*), and is more generally known, although *Murænopsis*, the three-toed genus, is the one which I studied.

[2] Smithsonian Contributions to Knowledge, Washington, 1853.

[3] Amphibiorum Nudorum Neuroglia ; also, Anat. Abhandlungen über die Perennibranchiaten und Derotremen.

[4] Zeitschrift für wiss. Zoologie, Band xx, xxv.

[5] Anatomical Technology, Wilder and Gage, 1883.

My method of study was: (1) A careful examination of the external features of the brain. (2) A series of very thin transverse and longitudinal sections of the brain, the sections after staining being carefully mounted in serial order. These series naturally supplement each other and give a very accurate idea of the gross and minute structure.

The technical process of preparing the brains was as follows: They were hardened, after removal from the skull, in a saturated solution of bichromate of potash, the acid being subsequently removed with alcohol of different densities. The brains were then embedded in an egg-mass prepared by shaking the white and yolk of egg together, with three drops of glycerine to each egg. This mass was first stiffened around the brain by placing in a vapor of alcohol, then hardened in absolute alcohol until ready for cutting. Its advantages are that it closely embraces the brain, holding all the parts together and becoming transparent in oil of cloves. The section cutting was done with one of the large instruments manufactured by Jung, of Heidelberg, which is far superior to any other instrument of its kind now in use.

External Structure. The brain of *Amphiuma* (Plate VIII, figs. A and B) resembles that of *Menopoma* (figs. C and D) more closely than that of any of the remaining Urodela. Its most striking feature is that the component parts are, in the main, little differentiated from each other, giving the exterior very much the simple character of an embryonic brain. This is especially true of the Di-, Mes- and Epencephala. The vertical longitudinal section (fig. H) shows that the construction of the interior is equally simple. The brain flexure is apparently slight. The brain is also extremely small in proportion to the body, and has a narrow, elongated form; a remarkable feature is the diminutive size of the cerebellum. This general simplicity corresponds to the partial blindness and to the degenerate structure and habits of *Amphiuma.*

---

[1] The following are some of the terms employed and their synonyms: *Rhinencephalon*, olfactory lobes; *Prosencephalon*, including the cerebral hemispheres and their cavities (*procœliæ*); *Diencephalon*, including the thalami optici, the infundibulum, the pineal gland, etc., and the *diacœlia* or third ventricle; *Mesencephalon*, including the optic lobes, the crura cerebri and *mesocœlia* or iter; the *valvula*, or valve of Vieussens; *Epencephalon* or cerebellum; *Metencephalon*, medulla oblongata, and roof of fourth ventricle.

The *Metencephalon* is very broad and shallow, with its upper surface divided longitudinally by a central and two slight lateral furrows, and with its borders turning bluntly inwards anteriorly, apparently to enter the cerebellum. On its lower surface the medulla is divided by the central furrow, a continuation of the anterior fissure of the spinal cord. As in other Amphibia, the medulla passes without clear demarkation into the crura cerebri.

The *Epencephalon.* The cerebellum is a narrow, band-like structure, arching across the wide medulla. It is unusually small, and was actually overhung by the optic lobe in my specimens, so as not to be seen in the median line, although this point may require confirmation. The valvula is therefore out of sight, in the dorsal aspect of the brain, but may be seen in the longitudinal sections.

The *Mesencephalon.* The optic lobe has no longitudinal furrow, but forms a single, narrow, unpaired body, passing forward into the roof of the Diencephalon without demarkation. These divisions of the brain cannot be distinguished upon the dorsal surface, but can be seen in side view by noting the position of the infundibulum below. The *Crura* (pars peduncularis) form a broad base for the posterior half of the Mesencephalon, which, by an oversight, is not represented in the drawings. As they pass forward, however, they cannot be distinguished from the optic lobe nor from each other, so that this division of the brain forms a cylindrical tube, the component parts of which can only be detected in the microscopic structure.

The *Diencephalon.* The roof of this portion of the brain terminates anteriorly in the large pineal gland; its median surface is marked, in *Menopoma*, by two circular thickenings which were not noticed in *Amphiuma.* These may correspond to several structures in the brain roof, which are apparent in the sections. The sides of the Diencephalon form the thalami, but the prominent feature of this portion of the brain is the production of the floor into the long, backward-directed infundibulum, which is best seen in side view. At the base of this process is the large pituitary body. At the sides of the infundibulum are two thickenings which converge to enter the thalami; their relations are clearly shown in the sections. In front of the infundibular region the Diencephalon as a whole becomes higher and narrower. There is quite a space between the infundibulum and optic chiasma; the latter has no clear decussation of fibres as in the frog; on the other hand, the nerves are given off as two slender fibres on either side of a slightly raised whitish plate.

The *Prosencephalon*. The cerebral hemispheres are very long, flattened-oval bodies, narrowing forwards; they are in close contact, but there is no structural union, except for a short distance in front of the lamina terminalis. The *Rhinencephala* arise from the outer anterior third of the hemispheres and give off on the lower surface of the brain, the large olfactory nerves.

INTERNAL AND MICROSCOPIC STRUCTURE.

The internal structure of the brain, so far as studied, has many interesting features, which may here be considered in connection with the various divisions of the brain tube, concluding with some observations upon the general distribution of the gray and white matter. It must here be said that the minute histology has not been so carefully studied as to afford conclusive data.

Fig. H represents a longitudinal vertical section of the brain of *Amphiuma*, magnified four diameters, the shaded portions showing the gray or cellular matter. The vertical lines indicate, approximately, the position of twelve of the thirteen transverse sections which are figured. Fig. 9 passes through the anterior commissure and the forward portion of the diacœlia, not quite agreeing with any vertical line that could be drawn through fig. H. Much enlarged longitudinal and transverse views of the cerebellum are given in E and F. Fig. G gives an imperfect idea of some of the cells found in the crura.

The *Epencephalon* is the only division of the brain which has a complete investment of gray matter; this statement needs the reservation that the cells surrounding the cerebellum *may* be of epithelial origin, although this doubt is apparently disproved by the close similarity and continuity of their structure with those of the optic lobe. If this be admitted, the cerebellum is composed of three parts: (1) A continuous band of fibres arching from side to side of the medulla. (2) A fine layer of fibres which have an antero-posterior direction. (3) An investing layer of cells one or two rows deep. These parts are represented in fig. E, *b*, *a* and *c*; also in fig. F, *b* and *c*.

(1) The *transverse band* of fibres (fig. 1) form the greater part of the cerebellum; they appear to arise from columns of fibres in the lateral portions of the medulla, so that they correspond partially to the inferior peduncles of the mammalian cerebellum arising from the restiform bodies. (2) The fine layer of fibres have a direction at right-angles to these, and are three or four deep, seeming to terminate in the lateral portions of the cerebellum, in some cells lying between the cerebellum and the optic lobe. This layer, owing to the peculiar position of the cerebellum beneath the optic lobe, is dorsal to the main transverse band; if the cerebellum were turned backwards, this layer would be ventral to it. (3) The cells composing the cortex of the cerebellum are of an elongated-oval shape, usually one row, in some places two rows deep. Their greatest diameter is arranged parallel to the main band of transverse fibres. Here, as in other portions of the brain, it was difficult to ascertain whether or no these cells were continued into fibre processes. No such processes were discovered.

The above account differs widely from that given by Stieda[1] of the frog's cerebellum; although the latter is somewhat difficult to understand owing to the lack of figures.

The *Mesencephalon*. Posteriorly, the mesocœlia is broad and low, and the brain tube has a subpyramidal section; anteriorly, it becomes more circular and is surrounded by a shield-shaped mass of cells (figs. 2 and 3), surrounded in turn by the mass of longitudinal fibres, the whole constituting the optic lobe and crura. According to Stieda,[2] the brain of axolotl has a similar structure in this region.

The *Diencephalon* is the most interesting division of the brain; its deep but narrow cavity (diacœlia) is filled with the large choroid plexus; it has a very thin roof and floor, but broad lower sides. The *infundibulum* is formed by the thrusting downward of the posterior portion of the floor. Its walls are much convoluted; they are composed chiefly of white matter, with here and there a scattering of nerve-cells, which in some places form a continuous layer. The base of the infundibulum is closely reflected over the pituitary body as a thin lamina. The pituitary body has therefore no communication with the brain cavity, as has been observed in some animals. It is composed of a solid mass of granular cells, traversed by numerous blood-vessels, and resembles in structure, although more compact, one of the ordinary lymphatic glands.

---

[1] Zeitschrift für wiss. Zoologie, Band xx.

[2] Same Journal, Band xxv.

The lumen of the infundibulum becomes narrower before it communicates with the diacœlia, and the lateral walls become thickened into two solid oval masses, largely composed of nerve-cells. These bodies resemble the *lobi inferiores* of the Teleosts, and, according to Stieda,[1] correspond in position with the tuber cinereum of the mammalia; anteriorly they gradually converge (figs. 4 and 5), finally entering the thalami. At this point the diacœlia has a cruciform shape, the lateral cavities separating the tuber cinereum from the walls of the Diencephalon above. In front of this is the thickening of the optic chiasma, and around the upper portion of the ventricle is a row of compact cells which resemble columnar epithelium. Anteriorly the latter flatten out, covering a lateral expansion of the ventricle. Above this is a small hollow sphere formed of a single layer of cells (fig. 7, *x*); the meaning of this structure is not known, and no mention of it has been found by the writer elsewhere. It corresponds in position with the external markings noticed upon the dorsal surface of the Menopoma brain at this point (see fig. C, *Di. t.*). Immediately below this point is a transverse band of nerve-fibres which probably belong to the optic chiasma.

The roof of the Diencephalon is of irregular thickness; forward it is carried as a very thin lamina over the *pineal gland.* The structure of this body is nothing more than a rich plexus of blood-vessels produced from the choroid; in the apex are numerous fine nuclei, resembling those of connective tissue, certainly not of nerve-tissue. There is no evidence that the latter is present.

It will thus be seen that the pineal body is a simple vascular structure, properly speaking, in communication with the brain cavity, since it is apparently surrounded by the brain parietes. The pituitary body, on the other hand, is a compact glandular structure, not in apparent communication with the brain cavity, except by an improbable process of osmosis through the attached cells.

---

[1] Stud. über d. centrale Nervensystem d. Knochenfischer. Zeits. für wiss. Zoologie, Band xviii.

The sections are imperfect in the forward portion of the root of the Diencephalon (*diatela*); they do not show the *postcommissura*, described by Stieda and Wilder. The *præcommissura*[1] has its usual shape and position.

The relations of the Diencephalon to the *Prosencephalon* are shown in figs. 7, 8 and 9. The procœliæ extend back into the posterior sections of the hemispheres. Anterior to this the hemispheres fuse with the thalami below, receiving from the upper portion of the Diencephalon a conspicuous band of fibres (fig. 8, *a*). The relations of the dia- to the procœliæ are best obtained by means of horizontal longitudinal sections; these have not been made as yet, so that the nature of these cavities is somewhat doubtful. It appears that the procœliæ communicate with each other some distance anterior to the lamina terminalis.

The hemispheres have a great lateral extent, containing extensive cavities. Their posterior halves are partly fused together; anteriorly, however, they are quite separate and distinct, becoming more cylindrical in section in the region of the Rhinencephalon. A peculiar feature of each procœlia is the formation of a short superior median cornu (fig. 11, *a*); corresponding to this is an extension of the gray matter lining the cœlia to the cortex of the hemisphere. Forwards the cœliæ have a vertical and more internal position. The *Rhinencephala* arise in masses of gray cells in the anterior third of the lateral portions of the hemispheres; they do not contain any cavity, but are continued forward into the solid olfactory nerve.

The structure and distribution of the nerve-fibres and cells have not been closely studied; the following are some preliminary notes:

The cavities of the brain are throughout lined with masses of nerve-cells of varying thickness. Nerve-cells are also found scattered among the fibres, but these are somewhat rare. The gray substance lining the hemispheres corresponds to the *central gray*, the Höhlengrau of Meynert. At a few points it is found upon the brain cortex; these are: (1) the lateral bodies of the infundibulum (fig. 3); (2) the upper surface of the central portion of the hemispheres (fig. 11); (3) and the inner sides and front of the foremost portion of the same (fig. 12); (4) the cerebellum.

---

[1] Anterior and posterior commissures.

None of these cortical exposures of the central gray can be considered to correspond to the *cortical gray* (Rindengrau) of the mammalian brain. The gray substance is, therefore, chiefly central.

The scattered nerve-cells above referred to are principally found in the substance of the hemispheres above the cavities, internal to fig. 11, *a*. Here they are numerous.

The nerve-cells are chiefly small, oval and nucleated bodies, very compactly placed; among these at some points, as in the crura, much larger cells enveloped in loose capsules were discovered. No processes were found leading out of these cells, in fact no unmistakably branched cells were found at any point; this may have been the fault of the preparation methods, for Stieda has found that the branched nerve-cells are very numerous in the frog, while Wyman, employing simpler histological methods, failed to find them.

This is as far as the sections have been studied, although they offer very tempting opportunities for making out the nerve-tracts.

The following is a resumé of the results thus far obtained:

In external characters, *Amphiuma* differs widely from the frog type in the simpler differentiation of its parts, the mid-region of the brain being a rounded tube with no separation of its optic lobes and thalami indicated above. The cavities of the brain are equally simple, the meta-, meso- and diacœliæ forming a uniform cavity, forking into the procœliæ in front. The infundibulum has the large size which is so characteristic of it in the fishes, and its lateral bodies recall the *lobi inferiores* in the Teleosts, although passing forwards they form the tuber cinereum. The pineal and pituitary bodies are constructed upon clearly different principles, one being within, the other without the brain walls, the former a vascular plexus, the latter a gland. In the roof of the Diencephalon is a small spherical body whose meaning is not known, but which may prove to be of some morphological significance. The cerebellum has a cellular investment and consists of two sets of fibres with a transverse and fore and aft direction. The gray matter of the brain lines the cavities throughout, as the "central gray;" continuations of it extend in some places to the cortex, but the "cortical gray," if present at all, is very limited in distribution.

EXPLANATION OF PLATE VIII.

Illustrating the Brains of Amphiuma and Menopoma.

Lettering and Abbreviations.

Rh.—Rhinencephalon; *Pr.* and *Pro. c.*—Prosencephalon and Procœlia; *Di.*, *Di. t.* and *Di. c.*—Diencephalon, Diatela (roof of Diencephalon), and Diacœlia; *Me.* and *Me. c.*—Mesencephalon and Mesocœlia; *Ep.* and *Ep. c.*—Epencephalon and Epicœlia; *Met.*—Metencephalon.

Tc.—Tuber cinereum; *ch.*—optic chiasma; *pt.*—pituitary body; *pn.*—pineal gland; *in.*—infundibulum; *cho.*—choroid plexus; *cr.*—crura cerebri; *p. cm.*—præcommissura (anterior commissure); *th.*—optic thalamus.

I.—Optic; II.—Olfactory; III.—Oculo-Motor; V.—Trigeminis; VI.—Abducens; VII.—Facial; VIII.—Auditory; IX, X, XI.—Vagus Group. N. B.—The identification of the nerves was by noting their origin; the distribution of the nerves has not been worked out.

Special References in Figures.

Figures A–D, twice natural size. Figs. H and 1–13, eight times natural size.

Figure A. Dorsal view of the brain of *Amphiuma.*

Figure B. Ventral view of the same.

Figure C. Dorsal view of the brain of *Menopoma.*

Figure D. Lateral view of the same. Dit. corresponds to vertical line 7, fig. H.

Figure E. Enlarged view (about 30 diameters) of a longitudinal section of the cerebellum and a portion of the optic lobe, taken at one side of the median line. The valvula, *v*, is broader in the median line; *d*, white, *e*, gray portion of Mesencephalon; *a*, fine longitudinal fibres; *b*, transverse band of fibres; *c*, cortical layer of cells.

Figure F. Transverse section of the cerebellum, lettering as in fig. E.

Figure G. *a*, large, *b*, small cells found in crura cerebri (30 diameters).

Figure H. Longitudinal section of the brain of *Amphiuma*, taken to the left of the median line. Vertical lines, 1 to 13, correspond to transverse sections represented by figs. 1 to 13. Black line represents the pia mater; the roof of the metacœlia (fourth ventricle) is omitted in the drawing.

Figure 1. Vertical transverse section through cerebellum, showing it as a transverse band passing beneath Mesencephalon.

Figure 2. Ditto through pituitary body and infundibulum, showing crura cerebri and optic lobe unpaired.

Figure 3. Showing sides of infundibulum thickening into tuber cinereum.

Figure 4. Through posterior portion of the Diencephalon.

Figure 5. Through the median portion of the Diencephalon.

Figure 6. Slightly anterior to fig. 5. *y*, a constriction of the upper portion of the diacœlia.

FIGURE 7. Forward portion of Diencephalon. *y* corresponds to *y* in fig. 6 ; *x*, see *x* in fig. H.

FIGURE 8. Forward portion of Diencephalon. *a*, bands of fibres passing downwards into the hemispheres.

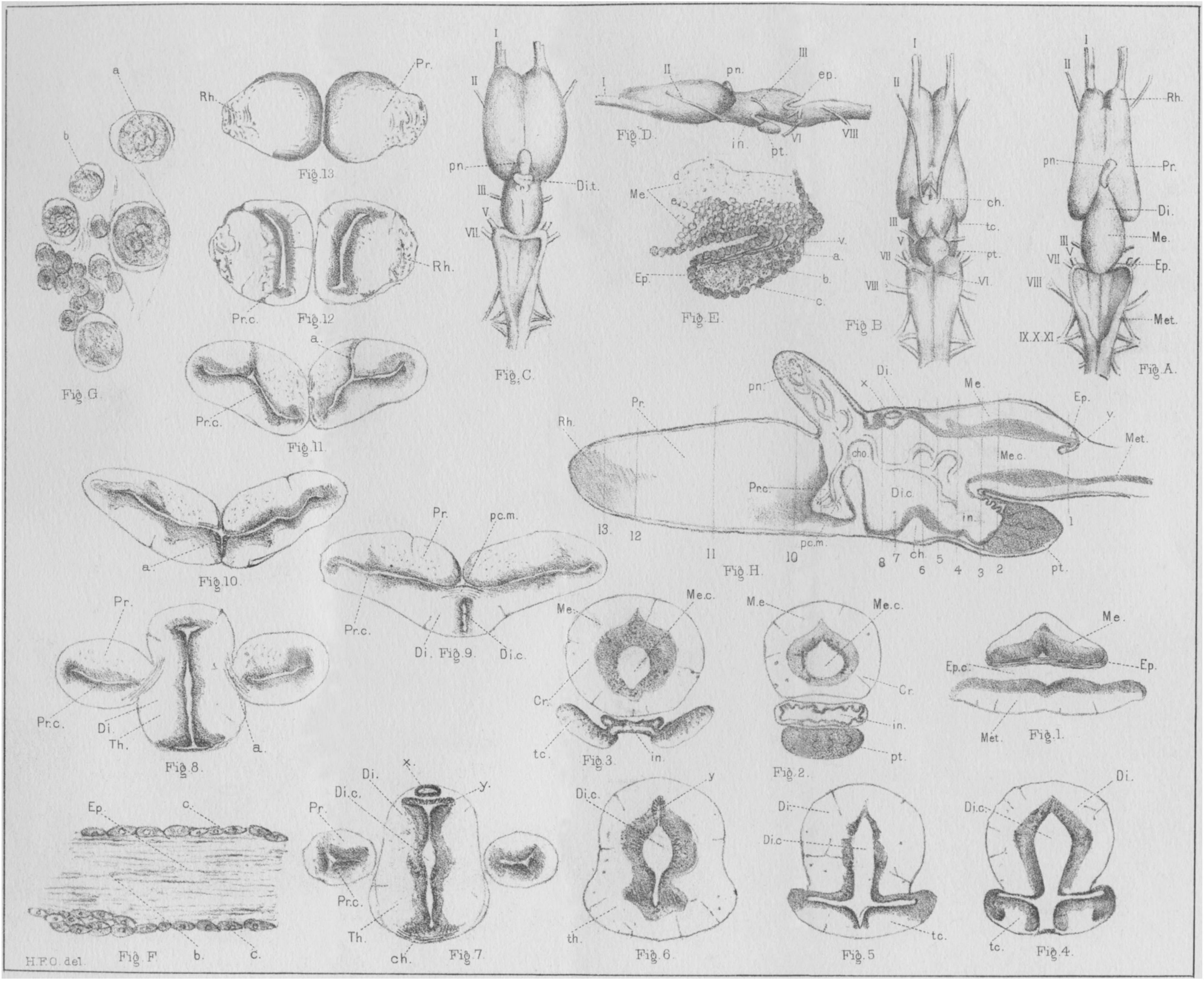
FIGURE 9. Forward lower portion of Diencephalon (*Di. c.*), showing præcommissura and procœlia.

FIGURE 10. Through the hemispheres slightly anterior to the lamina terminalis.

FIGURE 11. Median portion of hemispheres ; *a*, gray matter extending to cortex.

FIGURE 12. Anterior third of hemispheres ; showing the beginning of the Rhinencephalon.

FIGURE 13. Section near the tips of the hemispheres.



BRAIN OF AMPHIUMA